

# TRAINING AND EXPERIENCE OF EACH INDIVIDUAL NAMED IN ITEM 4 (Use supplemental sheets if necessary)

8. TYPE OF TRAINING	WHERE TRAINED	DURATION OF TRAINING	ON THE JOB (Circle answer)	FORMAL COURSE (Circle answer)
a. Principles and practices of radiation protection	Troxler electronic labs, Inc.		Yes No	Yes No
b. Radioactivity measurement standardization and monitoring techniques and instruments	Standard two(2) day training		Yes No	Yes No
c. Mathematics and calculations basic to the use and measurement of radioactivity			Yes No	Yes No
d. Biological effects of radiation			Yes No	Yes No

## 9. EXPERIENCE WITH RADIATION (Actual use of radioisotopes or equivalent experience)

ISOTOPE	MAXIMUM AMOUNT	WHERE EXPERIENCE WAS GAINED	DURATION OF EXPERIENCE	TYPE OF USE
Cesium 137 and Americium 241	8.5/50 MCI and 10/55 MCI	Soil Testing Services, Inc.	10 years	Density-Moisture measurement

## 10. RADIATION DETECTION INSTRUMENTS (Use supplemental sheets if necessary)

TYPE OF INSTRUMENTS (Include make and model number of each)	NUMBER AVAILABLE	RADIATION DETECTED	SENSITIVITY RANGE (mr/hr)	WINDOW THICKNESS (mg/cm <sup>2</sup> )	USE (Monitoring, surveying, measuring)
None					

## 11. METHOD, FREQUENCY, AND STANDARDS USED IN CALIBRATING INSTRUMENTS LISTED ABOVE

N/A

## 12. FILM BADGES, DOSIMETERS, AND BIO-ASSAY PROCEDURES USED (For film badges, specify method of calibrating and processing, or name of supplier)

R.S. Landauer, Jr. Co.

Glenwood Science Park

Glenwood, Ill. 60425

312/755-7000

## INFORMATION TO BE SUBMITTED ON ADDITIONAL SHEETS IN DUPLICATE

13. FACILITIES AND EQUIPMENT. Describe laboratory facilities and remote handling equipment, storage containers, shielding, fume hoods, etc. Explanatory sketch of facility is attached. (Circle answer) Yes No

14. RADIATION PROTECTION PROGRAM. Describe the radiation protection program including control measures. If application covers sealed sources, submit leak testing procedures where applicable, name, training, and experience of person to perform leak tests, and arrangements for performing initial radiation survey, servicing, maintenance and repair of the source.

Troxler Model 3880

15. WASTE DISPOSAL. If a commercial waste disposal service is employed, specify name of company. Otherwise, submit detailed description of methods which will be used for disposing of radioactive wastes and estimates of the type and amount of activity involved.

Source will be returned to

## CERTIFICATE (This item must be completed by applicant)

manufacture.

16. THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATE ON BEHALF OF THE APPLICANT NAMED IN ITEM 1, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH TITLE 10, CODE OF FEDERAL REGULATIONS, PART 30, AND THAT ALL INFORMATION CONTAINED HEREIN, INCLUDING ANY SUPPLEMENTAL INFORMATION, IS TRUE AND CORRECT TO THE BEST OF OUR KNOWLEDGE AND BELIEF.

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12-18754-02

PDR

License No.

Fee Enclosed \$

Foundation Engineering, Inc.

Applicant named in item 1

By: Chang H. Choi, P.E.

Date June 20, 1979

Radiation Protection Officer

Title of certifying official

**WARNING.**—18 U. S. C., Section 1001; Act of June 25, 1948; 62 Stat. 749; makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

UNITED STATES ATOMIC ENERGY COMMISSION  
APPLICATION FOR BYPRODUCT MATERIAL LICENSE

INSTRUCTIONS.—Complete Items 1 through 16 if this is an initial application or an application for renewal of a license. Information contained in previous applications filed with the Commission with respect to Items 8 through 15 may be incorporated by reference provided references are clear and specific. Use supplemental sheets where necessary. Item 16 must be completed on all applications. Mail two copies to: U.S. Atomic Energy Commission, Washington, D.C., 20545, Attention: Materials Branch, Directorate of Licensing. Upon approval of this application, the applicant will receive an AEC Byproduct Material License. An AEC Byproduct Material License is issued in accordance with the general requirements contained in Title 10, Code of Federal Regulations, Part 30, and the Licensee is subject to Title 10, Code of Federal Regulations, Part 20, and the license fee provisions of Title 10, Code of Federal Regulations, Part 170. The license fee category should be stated in Item 16 and the appropriate fee enclosed. (See Note in Instruction Sheet).

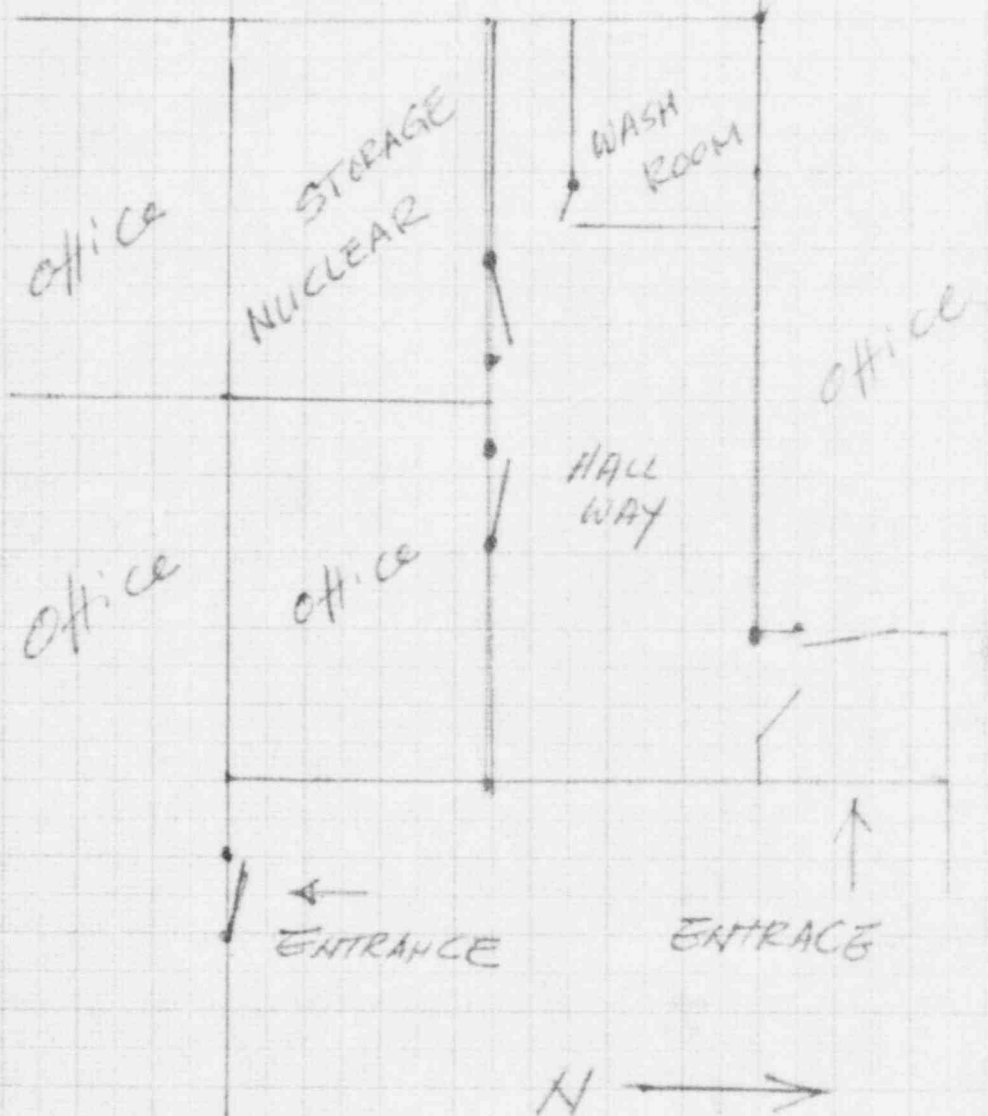
1. (a) NAME AND STREET ADDRESS OF APPLICANT (Institution, firm, hospital person, etc. Include ZIP Code and telephone number.)	(b) STREET ADDRESS(ES) AT WHICH BYPRODUCT MATERIAL WILL BE USED. (If different from 1(a). Include ZIP Code.)
Foundation Engineering, Inc. 1853 Hicks Road  Suite A Rolling Meadows, Ill. Tel. 312-882-2450	Throughout the state of Illinois on various construction projects.
2. DEPARTMENT TO USE BYPRODUCT MATERIAL  Quality Control Department	3. PREVIOUS LICENSE NUMBER(S). (If this is an application for renewal of a license, please indicate and give number.)
4. INDIVIDUAL USER(S). (Name and title of individual(s) who will use or directly supervise use of byproduct material. Give training and experience in Items 8 and 9.)  Chang H. Choi, Supervisor	5. RADIATION PROTECTION OFFICER. (Name of person designated as radiation protection officer if other than individual user. Attach resume of his training and experience as in Items 8 and 9.)  Chang H. Choi

6. (a) BYPRODUCT MATERIAL. (Elements and mass number of each.)  Cesium 137  and  Maericium 241:  Berylium	(b) CHEMICAL AND/OR PHYSICAL FORM AND MAXIMUM NUMBER OF MILLICURIES OF EACH CHEMICAL AND/OR PHYSICAL FORM THAT YOU WILL POSSESS AT ANY ONE TIME. (If sealed source(s), also state name of manufacturer, model number, number of sources and maximum activity per source.)  Sealed source as per Troxler drawing #a-102112 Maximum of 8 mCi $\pm 10\%$ per source  and  Sealed source as per Troxler drawing #a-102451 Maximum of 40 mCi $\pm 10\%$ per source
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7. DESCRIBE PURPOSE FOR WHICH BYPRODUCT MATERIAL WILL BE USED. (If byproduct material is for "human use," supplement A (Form AEC-313a) must be completed in lieu of this item. If byproduct material is in the form of a sealed source, include the make and model number of the storage container and/or device in which the source will be stored and/or used.)

For use in a Troxler Moder 2401 Compac surface moisture-density gauge.

SKETCH FOR NUCLEAR HANDLING & STORAGE  
APPLICATION FOR RADIOACTIVE MATERIAL LICENSE  
By FOUNDATION ENGINEERING, INC.



# THE ROAD/READERS

## THE 3400B SERIES SURFACE MOISTURE-DENSITY GAUGES

The 3400B Series is specifically designed to measure the moisture content and density of soils, soil-stone aggregates, cement and asphalt treated bases, and asphalt paving. With suitable calibration, it can also be used to measure these parameters of other materials having approximately the same range of density and/or moisture content.

The 3400B Series incorporates the latest state-of-the-art in solid-state semiconductor design to provide a high degree of accuracy and reliability. The nuclear geometry and radioactive source design are the culmination of some twenty years of Troxler research and experience in developing instruments of this type. In addition to laboratory work, user experience of approximately 5000 instruments aided in the

selection of the required design criteria and desirable end specifications.

The 3400B Series features simultaneous moisture and density measurements in both the Backscatter and Direct Transmission test modes; greatly extended operation between battery recharges and increased battery life; liquid crystal display which allows increased readability in high ambient light conditions; greatly improved Backscatter performance; and simplified operation to reduce operator error.

*The Model 3411B contains a micro computer which holds all calibration constants and algorithms necessary to compute and display directly, wet density, moisture, dry density, percent moisture, and percent compaction in either kilograms per cubic meter or pounds per cubic foot, as chosen by the operator. The Model 3411B eliminates*

the error in wet density due to the presence of hydrogen in the measured sample. The error is created by the high mass attenuation coefficient of hydrogen. This correction has not been possible in earlier gauge models. The Model 3411B also provides a means of compensating the moisture measurement for hydrogen that is present in the measured material, and is not in the form of free water.

The Model 3401B offers the customer a quality instrument at a lower cost. A simple calculation must be made by the gauge operator and measurement results determined by the use of computer derived calibration tables. The Model 3401B can easily be converted into a Model 3411B by changing scaler modules.

**FROM TROXLER®**

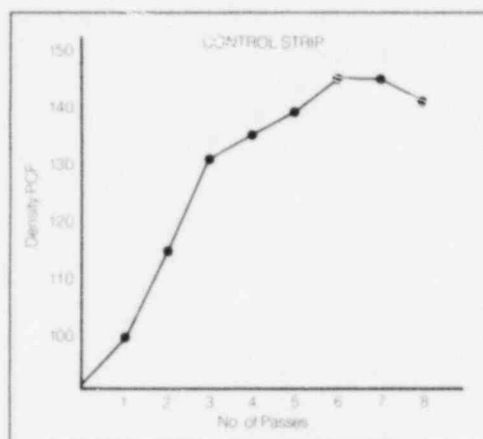
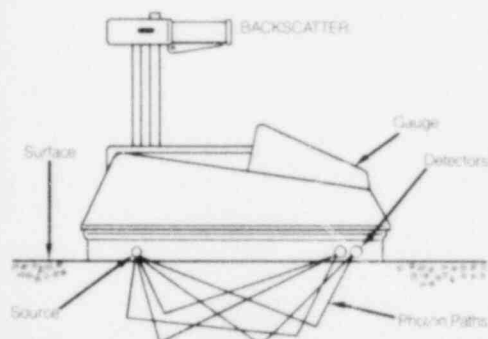


## DENSITY TEST MODES

The 3400B Series offers two test modes for measuring the density of construction materials. The operator may choose either Backscatter or Direct Transmission, depending upon the material and the thickness of the lift to be tested.

## BACKSCATTER

The Backscatter method is non-destructive and may be performed rapidly. Both the gamma source and detectors remain on the surface. Gamma rays enter the material and those scattered back into the detectors are counted. Backscatter is generally insensitive to changes in density below 3.5 inches, which limits its use to thin lifts of material. Backscatter is recommended primarily for use on asphaltic concrete. The 3400B Series has greatly improved Backscatter performance in sensitivity and reduced surface roughness error. With a .05" 100% void underneath the gauge, the surface roughness error is 4.0 PCF, which is one-half that of previous models.



A widely used Backscatter technique for stone base and asphaltic concrete lifts is the "control strip" method. The procedure involves the construction of a 400 sq. yd. test section of representative material. Compaction is accomplished with selected rollers and nuclear Backscatter tests are performed after each roller pass until no further increase in density is observed. Maximum density is determined by taking the average of 10 randomly selected tests. Nuclear tests are normally run on 2800 sq. yd. sections and must average 98% of the target density, with no single test falling below 95%. A new test section must be established when a change of material occurs or after 10 sections have been approved. The obvious advantage of the nuclear gauge on hot asphalt is a quick, on-the-spot test which pinpoints areas needing compactive effort while the asphalt can still be worked.

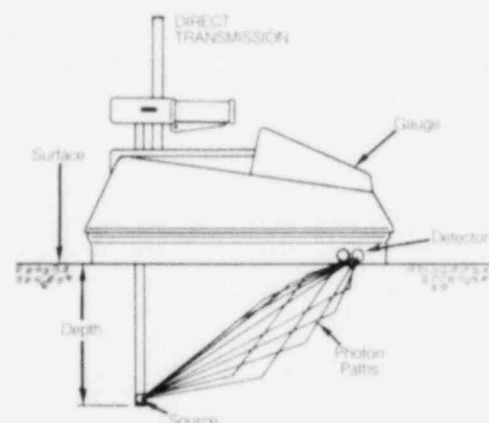
The Model 3411B allows the entry of Marshall values (maximum obtainable density of asphalt) and will compute and display percent compaction of wet density.

If proctor densities are not used for compaction control, the specific gravity of the solids may be entered instead of the proctor value. This will enable the operator to determine the percent solids. A simple subtraction will then allow the operator to determine percent voids.

## DIRECT TRANSMISSION

Direct Transmission is a pseudo non-destructive test which places the gamma source into the material by means of a punched access hole. Standard gauges have eight inch depth capabilities in two inch increments. One inch increments are available by special

order. A special twelve inch depth capability with one or two inch increments may also be ordered. Gamma rays are transmitted from the source through the material to be measured to the detectors located on the surface. The average density of the lift of material is determined. Direct Transmission allows the operator to choose the depth of measurement and greatly reduces error resulting from surface roughness and chemical composition of the test material. Gauge precision is also improved. Direct Transmission is used primarily for testing medium to thick lifts of soil, stone base, and asphalt.



The 3411B also allows the entry of Proctor values for soil and soil aggregate. The micro computer will process the data and display percent moisture and percent compaction of dry density.

Current approved standards for nuclear density testing include ASTM D-2922-78, "Standard Test Method For Density (Of Soil And Soil-Aggregate In Place By Nuclear Methods) (Shallow Depth)", and ASTM D-2950-74, "Standard Test Method For Density Of Bituminous Concrete In Place By Nuclear Method".

## MEASUREMENT SPECIFICATIONS

	25 MIN	1 MIN	4 MIN	
BACKSCATTER DENSITY				
Precision at 120 PCF	1.04	.52	.26	±PCF
Composition Error at 120 PCF	2.5	2.5	2.5	±PCF
Surface Error (.05" 100% void)	4.0	4.0	4.0	-PCF
Expected Total Error	3.9	3.4	3.3	±PCF
Depth of Measurement (98%)	4.0	4.0	4.0	inches

## DIRECT TRANSMISSION DENSITY

Precision at 120 PCF 6" Depth	.48	.24	.12	±PCF
Composition Error at 120 PCF	1.4	1.4	1.4	±PCF
Surface Error (.05" 100% void)	0.9	0.9	0.9	-PCF
Expected Total Error	1.8	1.6	1.5	±PCF
Depth of Measurement	2-8	2-8	2-8	inches

## MOISTURE CONTENT

Precision at 15 PCF	.64	.32	.16	±PCF
Surface Error (.05" 100% void)	1.1	1.1	1.1	-PCF
Expected Total Error	1.5	.90	.70	±PCF
Depth of Measurement at 15 PCF	7.0	7.0	7.0	inches

## RADIOLOGICAL SPECIFICATIONS

Gamma Source	8 mCi cesium-137 (Troxler Drawing #A-102112)
Neutron Source	40 mCi americium 241 be, 70,000 neutrons/second (Troxler Drawing #A-102451)
Source Encapsulation	Stainless steel doubly encapsulated
Shielding	Tungsten and lead
Surface Dose Rates	15 mrem/hr maximum, neutron and gamma
Shipping Case	DOT 7A, Yellow II Label, 0.1 Transport Index

## MECHANICAL SPECIFICATIONS

Case	Epoxy finish aluminum casting
Vibration Test	0.1 inches at 12.5 Hz
Drop Test on 1" Steel Ball	12 inch height
Operating Temp:	
Ambient	-10°C to 70°C
Surface	175°C
Size	14.5 x 9 x 7.2 inches
(excluding handles)	(36.3 x 22.5 x 18 cm)
Total Height	19.5 inches (49 cm)
Weight	36 pounds (16.4 Kgm)
Shipping Weight with ABS case	85 pounds (38.6 Kgm)

## ELECTRICAL SPECIFICATIONS

Timer Accuracy and Stability	±.005% ±.0002%/°C
Readout (direct sunlight viewing LCD)	4 digits
Number of Count Registers	2-Model 3401B/ 4-Model 3411B
Stored Power	40 watt-hours
Power Consumption	0.12 watts
Recharge Time	16 hours
Charger Input	110/220 VAC, 50-60 Hz or 12-14 VDC

## ACCESSORIES

### ACCESSORIES SUPPLIED WITH GAUGE

Scraper plate/drill rod guide
Drill rod
110/220V, 50-60 Hz charger
Heavy-duty cardboard shipping container with insert
Reference Standard
Manual
Calibration table

### OPTIONAL ACCESSORIES

Metric calibration
12 inch (30 cm) depth
1 inch (2.5 cm) increments
High impact plastic ABS transport case
3400 Series tool kit
Model 3880 leak test kit
Molykote lubricant, spray & paste
2 amp buss type GMW fuse
Radiological survey meter
Model 3940 Scaler Test Station
Model 3954 PROM Programmer
Model 3960 Microprocessor Test Station
12-14 VDC charger

key board, and display. It is factory programmed with calibration constants to compute wet density, dry density, moisture, percent moisture, and percent compaction. Results may be displayed in either U.S. Customary or metric units.

The micro computer automatically corrects wet density readings for errors caused by the high mass attenuation coefficient of hydrogen found in the measured material. The true hydrogen density is evaluated, prior to any corrections for moisture content, and is used to correct the wet density which significantly improves the density accuracy. The Model 3411B also allows the insertion of a K factor to correct for hydrogen in the measured material which is not contained as free water. This moisture correction factor is applied, after comparison of conventional and nuclear moisture test data, by means of moisture correction switches located at the bottom of the scaler module. Plus or minus corrections may be entered by the operator. The K factor automatically adjusts for changes in dry density. This is necessary since the material causing the error by moderation of fast neutrons or absorption of thermal neutrons is contained in the dry soil and is not a part of the moisture content.

## CALIBRATION

The Troxler moisture and density calibration technique is the unique product of years of research and development. Only Troxler customers have the advantage of this sophisticated and accurate calibration method.

## DENSITY CALIBRATION

Count rate data is accumulated on five standard density blocks for the determination of density versus count rate computations and one standard density block to verify calibration accuracy. Specific gravities of the three metallic standard blocks are known to an accuracy of 0.1%, and of the natural material standards to 0.2%. A standard deviation of less than  $\pm 15$  PCF is assured for all data points.

Gauge response to density is by computer evaluation of the arithmetic

function:  $\text{Count Ratio} = A \cdot \text{EXP}(-B \cdot d) - C$ ; where  $d$ =density and  $A, B$  &  $C$  are constants determined on magnesium and aluminum standard blocks, and a combination magnesium and aluminum standard block. These constants obtained on the metallic standards determine the general shape of the calibration curve. Data is then taken on the limestone and granite standards and the values for the constant  $B$  are computed for these natural materials. The average of these two  $B$  values will produce a density calibration suitable for normal soils. A calibration validity check is then performed on a low density standard. In order to eliminate long-term effects of source decay and electronic drift, all data is normalized to a reference standard and expressed as a ratio. The calibration constants are stored in non-volatile memory in the Model 3411B.

Gauge parameters of precision, composition error, surface roughness error, and the root-mean-square sum of errors are determined for each gauge to predict probable field error. Computer calibration printouts are furnished for each density test mode and depth from 70 PCF to 170 PCF in  $\frac{1}{2}$  PCF increments. Metric calibrations are available upon request.

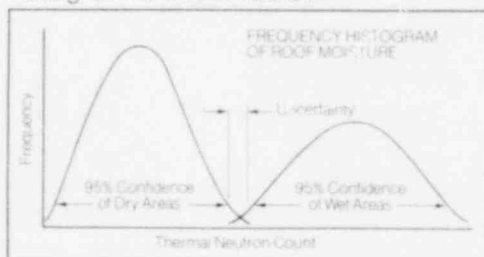
## MOISTURE CALIBRATION

Two moisture calibration standards, magnesium, which represents zero moisture, and a permanent moisture standard which is 36 PCF moisture, are used for the 3400B moisture calibration. Count rate data is normalized to a moisture standard count to eliminate the effect of long-term electronic drift in the instrument. These count ratios are then used to solve the equation:  $\text{Count Ratio} = E + F \cdot M$ ; where  $E$ =gauge response at zero moisture content,  $F$ =slope of the moisture curve, and  $M$ =moisture content. In the Model 3411B, the moisture calibration constants are stored in a non-volatile memory.

The moisture performance parameters of precision, surface roughness, and the expected field error are determined for each gauge. Computer moisture calibration printouts are provided for a range of 0 PCF to 40 PCF in  $\frac{1}{4}$  PCF increments.

## SPECIAL ROOF MOISTURE APPLICATION

The 3400B Series can be used to evaluate the degree of water migration within layers of a built-up flat roof. A ten by ten foot grid is laid out on the roof and non-destructive nuclear moisture counts are taken at grid intersections. A frequency histogram is next plotted of all the data points and used to identify wet and dry areas. A typical bimodal histogram is shown below.



With this type of distribution, the 95% confidence limits can be established for a normal distribution. Core samples are taken in areas which indicate definite wet conditions to determine the amount of moisture present. Once the wet threshold has been determined, a gridded roof drawing can be prepared and used to map the roof for repairs.

## LICENSING INFORMATION

The radioactive sources are by-product materials and do require a special license which is issued by an "agreement state" or by the Nuclear Regulatory Commission. Troxler will assist the customer in obtaining and completing the proper license application. Required radiological safety training courses are held periodically in the home office and in Troxler branch offices. A nominal fee is charged. Field training may also be arranged for a fee covering the instructor's time and applicable expenses.

# TROXLER®

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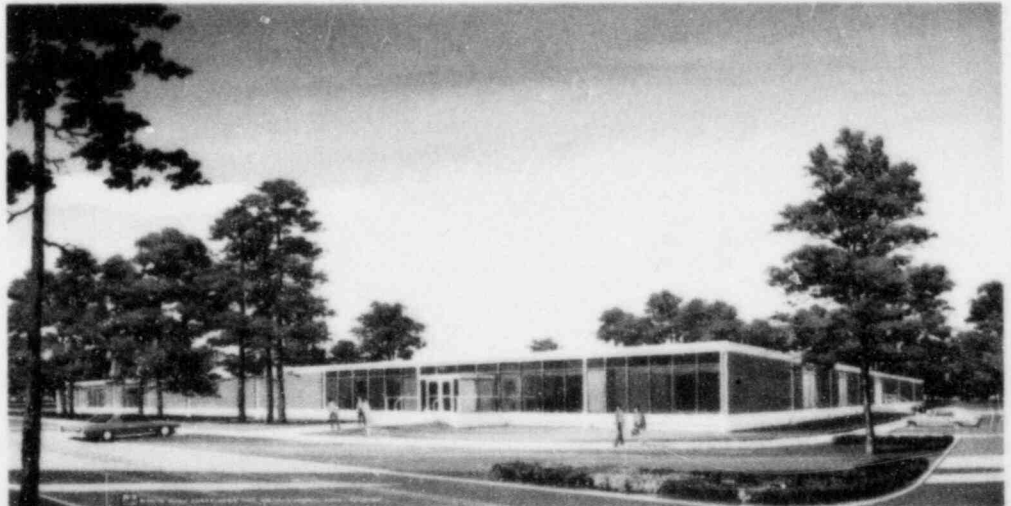
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AC 312/587-7273

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AC 503/638-2523

International sales handled through our  
subsidiary, Troxler International, Ltd.



## MOISTURE

The moisture measurement is non-destructive with the neutron source and detector both located on the surface of the test material. A field of fast neutrons enters the material and thermalization occurs after a series of collisions between the neutrons and hydrogen atoms present in the test material. The helium-3 detector, located in the gauge, detects the thermal neutrons.

It is suggested that factory moisture calibration data be compared to oven dry methods and adjustments be made, if necessary. *The Model 3411B has a "built-in" provision to allow the insertion of a correction factor for hydrogen which is not contained in the free water removed during standard oven drying procedures. This correction factor automatically adjusts for changes in the dry density of the soil which contains the moderator or neutron absorber.*

The ASTM Standard D-3017-78 "Standard Test Method For Moisture Content Of Soil And Soil-Aggregate In Place By Nuclear Methods" (Shallow Depth) is the current approved standard. The 3400B Series instruction manual details the procedure for obtaining moisture correction factors.

## MECHANICAL STRUCTURE

The 3400B Series instruments are housed in a permanent-mold aluminum casting which is heat treated and annealed to provide a rugged structure which is immune to physical damage except for major accidents. There are no openings from the bottom surface to the interior which would allow ground water or soil to enter the instrument. All topside openings are gasketed to maintain a clean environment. The instrument can sustain repeated drops from twelve inches (30 cm.) on a one-inch (2½ cm.) steel ball placed on the unyielding surface without damage or alteration of calibration. The exterior of the housing is either anodized or coated with epoxy paint.

The source rod is manufactured from stainless steel, hardened to 45-55 Rockwell C to reduce wear and insure proper indexing of the measurement geometry. The source rod is positioned in stainless steel linear bearings. The indexing mechanism is made from 4130

steel, hardened to 45 Rockwell C so that any wear is produced on parts which are easily replaced.

All interior parts are either anodized aluminum or stainless steel to prevent corrosion.

## RADIOLOGICAL

The instrument contains two sealed sources — an eight millicurie glass-bead source of cesium-137 to provide gamma radiation for the density measurement and a forty millicurie americium-241 beryllium source yielding seventy thousand neutrons per second for the moisture determination. Both sources are doubly encapsulated in stainless steel, and fusion welded.

All biological shielding is constructed of tungsten having a specific gravity of eighteen, a high gamma attenuation coefficient and a melting point of over 3,000°C. While more expensive than lead, tungsten insures permanent protection since it does not cold flow nor melt under conditions likely to be imposed on the instrument by fire.

Radiation levels on any surface of the instrument are less than fifteen millirem-per-hour, including both gamma and neutron. The dose rate at four inches (10 cm.) from any surface of the gauge are less than five millirem per hour. Packed in its transport or shipping case, the instrument meets all applicable requirements of the Department of Transportation under 7A designation.

## BATTERIES

The 3400B Series operates on two nickel-cadmium battery packs with a capacity of 40 watt hours. *A 3400B Series gauge can operate for approximately eight weeks on a full charge. Under normal conditions and using recommended charging procedures, the battery packs should never need replacing.* Recharge may be made overnight by use of a 110/220 volt 50-60 Hz charger or by means of a DC charger plugged into a cigarette lighter using 12 volt vehicle power.

## DETECTORS

Two high temperature platinum lined Geiger-Mueller detectors are used for density determinations. Platinum greatly increases the efficiency and life of these detectors which are manufactured to rigid Troxler specifications. Years of research and nuclear gauging experience have contributed to the design of these highly efficient detectors.

One helium-3 detector is used for the moisture measurement. This detector is specifically designed for use in the Troxler 3400B Series. This helium-3 detector is totally insensitive to gamma radiation below one Mev. This insures no interaction from the cesium-137 gamma source.

## ELECTRONIC ASSEMBLIES

*All 3400B electronic assemblies are packaged in modules which allow 100% field replacement by unskilled personnel. No adjustments or plateau procedures are required to obtain stable operation of the detectors. High voltage and counting thresholds are stable to within  $\pm 0.1\%/^{\circ}\text{C}$ . All components are selected to insure operation over an ambient temperature range of  $-10^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . All electronic circuits utilize CMOS large-scale integrated circuits for increased reliability, reduced complexity, and longer battery life.*

Three timing periods have been included which allow measurements to be made in either fifteen seconds, one minute, or four minutes. Timing periods are separated by statistical factors of two. The four digit liquid crystal display indicates readings which are one minute rates regardless of the timing period selected. *Bright sunlight enhances the readability of the liquid crystal display and shading is never required.* Notations are included to indicate a low battery condition and that the instrument is in the process of accumulating data.

Model 3411B reference standard counts for both moisture and density are stored in accumulators and can be addressed and read at any time. The accumulator contains both the moisture and density measurement counts in addition to the standard counts and any one of the four may be addressed and displayed as desired.

The 3411B micro computer has 3 user activated test routines which will verify proper operation of panel switches.